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Implementation conditions for energy saving technologies and practices in office buildings: Part 1. Lighting

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ABSTRACT

This paper provides a review of lighting energy saving and energy efficiency policies and practices in office buildings. The results of a face to face survey of 685 managers of companies are presented, which give insights into the factors that have influenced them to invest in lighting saving technologies. The assessment of the available lighting technologies in use in office buildings, showed that the installation of lighting saving technologies was positively influenced by a number of parameters, such as high annual financial turnover, recently established companies and companies managed by older, highly educated and energy aware people. The acceptability of the adoption and use of new efficient lighting technologies and the willingness to pay for proposed new efficient office lighting technologies, following a technico-economic information session, were also investigated. The willingness of a manager to invest in lighting energy saving/efficient technology was positively influenced by a number of factors including when a company was located in old buildings, if it was companies affected by electricity shortages, and/or if it had a large floor area.

Contents

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1. Introduction

The energy consumption in buildings, the energy requirements for lighting and the lighting saving/efficiency in offices are discussed in this section.

1.1. Energy consumption in buildings and climate change policy

Serious concerns about the depletion of fossil fuels, climate change and increased energy import dependency led Europeans leaders in March 2007 to make a long-term commitment for the mitigation of climate change and for energy sustainable development in the European Union. The transformation of Europe into a highly energy-efficient and low-greenhouse-gas emitting economy can be achieved by the endorsement of a combined climate and energy policy package with the following targets [1]: A 20% reduction in greenhouse gas emissions by 2020 compared to those in 1990; 20% integration of renewable energy sources into the final energy mix compared to the present 6.5%; an energy saving of 20% of the primary energy consumption in 2020 compared to the base year 1990. The direct cost, at European level of using energy efficiently, will amount to more than 100 billion euros annually by 2020. Realizing this 20% potential in 2020 will require an “Action Plan for Energy Efficiency” equivalent to some 390 Mtoe and to a reduction of CO_2 emissions by 780 Mt CO_2 with respect to the baseline scenario [2]. The Action Plan is intended to mobilize the general public, the policy-makers and the market actors in order to provide EU citizens with the most energy-efficient infrastructure, buildings, appliances, processes, means of transport and energy systems available globally.

The adopted 2002/91/EC Energy Performance of Buildings Directive -EPBD [3] is considered a very important legislative component of the energy efficiency activity of all member States of the European Union. It was designed to meet the Kyoto commitments and respond to issues raised in the Green Paper on energy supply security [4]. The “EC Action Plan for Energy Efficiency” identifies energy efficiency in the building sector as a top priority, with a key role for the EPBD corresponding to 28% energy saving in buildings, which in turn can reduce the total EU final energy use by around 11% [2].

Buildings account for more than 40% of the energy used [5,6] and the building sector is responsible for over one third of energy related CO_2 emissions [7]. The energy consumption in commercial buildings is very high, and commercial buildings in developing countries account for three quarters of this total consumption [8]. Energy consumption in buildings in Europe has been increasing at a rate of 1.5% per annum since 2004 [9], with the fastest growth seen in the commercial and public sector [10]. This increase was due not only to parameters related to the need for lighting, office equipment and cooling–heating in work places, but also to irrational energy behavior practices [5,9,11,12]. The Association for the Conservation of Energy in UK proposed (based on the EU Building Directive) that freeholders of commercial properties should ensure that their buildings meet minimum energy efficiency performance standards on a periodical basis [13].

Energy in office buildings is mainly used for heating, cooling, lighting purposes and for office equipment [14]. Pérez-Lombard et al. [9] reported that HVAC systems consume close to 50%, lighting 15% and appliances 10% of the energy in non residential buildings. Savings of up to 15% of turnover in a typical office might be attainable from the design, management and use of the indoor environment [15]. Such savings are essential for Greece that is committed inside the EU for the Kyoto Protocol to reduce its annual GHG emissions by approximately 15,000 kt CO_2 equiv. during the period 2008–2012 [16].

1.2. Energy for lighting

Globally, grid based electric lighting consumes 19% of total global electricity production. The energy consumed to supply lighting, worldwide, entails greenhouse gas emissions of a scale equivalent: 1900 Mt of CO_2 per year [17]. According to Augenbroe and Park [18] about 20–25% of the electricity used in buildings and about 5% of the total energy consumption in the US is used for lighting. Mortimer et al. [19] reported that the potential energy saving from the application of different energy efficiency technologies in lighting was: 75% from the replacement of tungsten filament lamps with compact fluorescent lamps; 10% from the replacement of 38 mm diameter fluorescent tubes with 26 mm diameter fluorescent tubes; and 25% with replacement of tungsten filament display lights with tungsten halogen lamps.

The use of optimal lighting devices could also lead to energy savings due to the potential gains from a reduction in heating loads. The use of efficient lighting devices can substantially decrease the cooling load of buildings especially in southern countries [20]. Santamouris et al. [21] reported that with the use of fluorescent lamps (80 lm/W) in air-conditioned office buildings can reduce the cooling load by about 9%. Thus, upgrading lighting devices may lead to a considerable energy and cost savings [22].

1.3. Lighting saving/efficiency in offices

Member states should comply with the 2000/55/EC Directive [23] on energy efficiency requirements for ballasts for fluorescent lighting. The total lighting energy consumption in office buildings is regulated by the Directive 2002/91/EC [3] on the energy performance of buildings. Major savings can be obtained by better lighting system design and control: more efficient reflectors, varying light levels according to function; efficient use of natural light; and use of occupancy lighting sensors [21,24–27]. Furthermore, by managing the lighting in secondary spaces can lead to considerable energy savings [28,29].

Although the lifetime of fluorescent tubes is reported to be 5–10 times longer than that of incandescent lamps, and their luminous efficiency five times greater, hence releasing lower heat loads, consumers are highly sensitive to the installation cost of new appliances [30]. As revealed by a lighting program in Stockholm in 1989, the size and shape of the lamp and the weight of the new technology were parameters affecting the acceptability of this technology [31]. Public surveys may help evaluate the acceptance of new lighting technology [32]. In addition, the compact fluorescent lamp, if widely adopted, has the potential to reduce peak electric power loads significantly [33].

The high installation cost of advanced/new electricity saving technology, however, was a discouraging factor for the adoption of this technology [31,34]. Periodic payments in the electricity bills [31] and loans for large scale applications have been successfully applied to date [35]. Nevertheless, high tech lighting devises pay back in the long term, especially if used for long periods, during the day [36], a fact which should be emphasized to the user.

The EU Directive 98/11/EG [37] became a part of the Greek national legislation as of September 1999 and is the legal basis for classifying the energy efficiency of domestic lamps. It aims to illustrate the energy efficiency of the lamps to consumers (A to G) and thus make it easier for buyers to choose the best and most energy efficient product. A successful lamp replacement project in Greece involved the replacement of 120,000 bulbs in 2000–2001 resulting in an estimated energy reduction of 12 GWh. The program was co-coordinated by the Public Power Corporation (PPC) and provided fiscal incentives to customers for lamp replacements (*i.e.* gradual payment of the relevant investment cost through electricity bills).

It was applied mainly to the islands not connected to the mainland electricity grid [38].

Many organizations suggest that the building sector is a key sector for low-cost energy saving climate mitigation worldwide [39–41]. Furthermore, in the 25 EU countries the total office space reached 1139 km^2 in 2004 with 2% increase per year resulting in 22.78 km^2 new office space per year according to Van Tichelen et al. [42]. For these reasons (high saving potential and the continually increasing number of office buildings) this research has been conducted. The main aim was to assess the use of lighting energy saving technologies, awareness levels, acceptability criteria for efficient lighting technologies, current practices and behaviors related to lighting in office buildings in companies dealing with trade and services. The possibilities of incorporating and accepting efficient lighting energy saving technologies and the willingness to pay and to adopt such technologies after an information session were also investigated and assessed. To the best of our knowledge this is the first study of this kind and we aim to provide greater insight for policy makers in order to promote energy saving/efficient technologies, programs and practices in the business sector.

2. Research methodology

The research was funded by the Interreg IIIC program and was implemented by the Regional Energy Agency of Crete (REAC) in cooperation with the University of Crete [43]. The benefits of this research included the provision of targeted information and the raising of awareness among professionals for new and innovative energy saving technologies related to lighting and energy sustainable behavioral attitudes. This was achieved by the interview itself, the focused information session and the use of specific leaflets which were explicitly presented and handed out afterwards to the interviewees for further consideration. The respondents were professionals who owned or legally represented a company located in a building office. The questionnaire comprised seven parts. The first part consisted of some general warm up questions concerning the level of energy saving awareness and energy saving practices in their office buildings. The second part recorded characteristics of the building envelope and double glazing structures. The third part recorded information about the current lighting technologies used. The fourth part contained information concerning the heating technologies and practices in the office. The fifth part contained questions about the air-conditioning technologies and the related energy efficient behavior in the offices. The sixth part assessed the energy efficiency of office equipment technologies and their use and standby power saving capabilities and practices. Finally, the seventh part dealt with information about the identity of the firm and respondent's socioeconomic status. The most important findings are presented as a two part paper. This first part paper presents the results for the lighting energy saving technologies. The second part [44] presents results for double glazed windows, heating and air conditioning (A/C) energy saving technologies and behavior.

Data collected from the third part of the questionnaire aimed to assess the implementation level of lighting saving and energy efficient technologies and practices and the willingness to replace conventional lamps with lighting efficient energy lamps and occupancy lighting sensors. Modeling of the revealed and stated preferences shortlist those variables that make people invest in energy efficient lighting technologies. The first question of this part requested information about the types, numbers and watts per lamp type used. The aim was to assess the overall lighting energy level and lighting energy saving status. The interviewer inspected the building and helped the respondent to record down the relevant figures. In order to identify the variables that influence the ratio of installed energy efficient lamps, the variable W_1 was created after having converted wattage into equivalent wattage of no saving lamps. Then the percentage of those watts covered by energy efficient lamps was also calculated. Total wattage of energy saving lamps (ESL) was multiplied by a factor of 5. For example, for a 20 W energy efficient lamp, 100 W of conventional (incandescent) lamps was assigned. Similarly, conventional fluorescence lamps (CFL) were multiplied by a factor of 2.5, for instance a 36 W CFL was equated to 90 conventional watts. Nominal installed power of advanced fluorescence lamps (AFL) was multiplied by a factor of 3.375, for example, a 36 W AFL was equated to 120.15 no saving watts. Vacuum lamps (VL) were multiplied by a factor of 5, for example, a 35 W VL was equated to 175 no saving watts. Finally, watts of common incandescence lamps (CIL) and watts of halogen lamps (HL) were left unchanged. Based on these conversions, the percentage of total energy saving watts in the office, as illustrated by Formula (1), was calculated. These calculations are based on product characteristics of local market. Design of new lighting systems may involve new lamp technology with lower wattage and lamp numbers, resulting to energy savings [45]. According to this, W_1 ranged from 0% to 100%. To establish the parameters affecting W_1 a Tobit regression was employed.

$$W_1 = \frac{2.5 \times \mathrm{CFL} + 3.375 \times \mathrm{AFL} + 5 \times \mathrm{ESL} + 5 \times \mathrm{VL}}{2.5 \times \mathrm{CFL} + 3.375 \times \mathrm{AFL} + 5 \times \mathrm{ESL} + 5 \times \mathrm{VL} + \mathrm{CIL} + \mathrm{HL}} \quad (1)$$

where W_1, percentage of total wattage corresponding to energy efficient lamps; CIL, total nominal installed lighting power of common incandescent lamps in the office (watt); AFL, total nominal installed lighting power of advanced fluorescence lamps in the office (watt); CFL, total nominal installed lighting power of conventional fluorescence lamps in the office (watt); HL, total nominal installed lighting power of halogen lamps in the office (watt); ESL, total nominal installed lighting power of energy saving lamps in the office (watt); VL, total nominal installed lighting power of vacuum lamps in the office (watt).

In order to further investigate the factors which make people invest in energy saving in lighting by installing energy efficient lamps, another model was developed where the dependent variable W_2 was a dichotomous variable taking the value "1" if the respondent had at least one energy efficient lamp. From these two models, the maximum information on the factors leading to the installation of energy saving lighting bulbs could be obtained. The first model locates variables over the level for energy saving in lighting and the second model identifies what factors influence managers' decision to install energy efficient lamps.

Those interviewees who had incandescent lamps were provided with a specific information session stating the following: "*Lighting in a typical office accounts for 1/3 of the total electrical energy required. If an incandescent lamp is replaced with an energy efficient lamp which is on for 8 hours per day, then the mean cost of the lamp in the Greek market (5€) is paid back during the first year and then 6.5€ per year is saved over the lifetime of the lamp. In total 80€ will be saved in the lamp lifetime*" [46,47]. A card with a photo of the energy efficient lamps was also shown to the respondent at the same time. Then they were asked "*Would you replace the incandescent lamps of your office with energy efficient lamps that cost in total . . .€, when there will be a total saving of . . .€ during the first 5 years?*". For this question the interviewer had instantly calculated the cost figures of this question. A "Yes" or "No" answer possibility was given. If the response was no, then a reason was requested. In order to find out variables that make people willing to invest in energy efficient lamps, their response was modeled with W_3 being the dependent variable of their statement.

Respondents were then asked if they use any automation devices for energy saving and the following options were provided:

Table 1
Summary of the models.

Dependent variable	Description of dependent variable	Values	Model type
W_1	Percentage of energy efficient lamps	Scale	Tobit
W_2	Have installed at least one energy efficient lamp	1: yes, 0: no	Binary
W_3	Willingness to replace all incandescent lamps with energy saving lamps	1: yes, 0: no	Binary
W_4	Existence of occupancy lighting sensor	1: yes, 0: no	Binary
W_5	Willingness to install occupancy lighting sensor in auxiliary areas	1: yes, 0: no	Binary
W_6	Have installed up to date efficient systems of fluorescence lamps	1: yes, 0: no	Binary
W_7	Willingness to install new advanced systems of efficient fluorescence lamps replacing the older fluorescent technology	1: yes, 0: no	Binary

Sensors of natural lighting, occupancy lighting sensors, local lighting or timers. The next scenario focused on the occupancy lighting sensors. A model was applied, where the dependent variable W_4 was the existence of a lighting sensor in the office. Then, after an inspection of the office area, to estimate the needed units, managers were informed of what an occupancy lighting sensor is and the achieved energy saving [47]. The following information was reported to them: "*An occupancy lighting sensor, if installed in the appropriate rooms (i.e. WC, store room, photocopy room, etc.) costs 30€ including the installation, but this cost is paid back within 3.5 years*". At the same time respondents were shown pictures of such devices to make them understand their function. Then they were asked "*Would you be willing to install* ...#... occupancy lighting sensors that cost (# × 30€ =) ...€". The interviewer had instantly made these calculations, in order to provide the number of lighting sensors units and their total cost. In order to find out what makes people willing to invest in lighting sensors a model was applied were the dependent variable W_5 took the value "1" if the respondent was willing to install the recommended occupancy lighting sensors and "0" if the respondent was not willing to do so. The next model applied was for the dichotomous dependent variable W_6 which was the existence of up to date energy efficient fluorescence lamps in the office. Then, for respondents who already had fluorescents lamps, but not the up to date energy efficient fluorescence lamps, the following information was given: "An e*fficient fluorescence lamp system consists of one electronic ballast (new generation) fluorescence lamps of 18W each and a reflector, which costs 60€ (including the installation), but it can provide 35% energy saving, it better directs the light to the desired direction and the cost can be paid back during the life of the system (∼10 years)*". Then they were asked "*Would you be willing to install* ...#... advanced fluorescence units that cost (# × 60€ =) ...€?". The interviewer had instantly made these calculations, in order to provide the number of units and their total cost. At the same time, a photo of this system was shown to the respondent. In order to find out what makes people invest in up to date efficient fluorescence lamps a model was developed were the dependent variable W_7 took the value "1" if the respondent was willing to make this investment and "0" if the respondent was not willing. Consumer surveys have raised additional concerns for the use of new technology lamps apart from pure cost issues [48]. An important factor not addressed in this paper is lighting performance which may affect lamp use, regardless any cost savings [49–51]. Perceived lighting performance though may vary according to the user [52].

All cost figures were calculated as for the climatic and market conditions of Crete and refer to the period the data collection was carried out. A summary of the models developed in this paper is presented in Table 1.

3. Results and discussion

The data collected involved a sample of companies from the major towns in Crete. The research took place from December 2006 to May 2007. In total 685 valid face to face interviews were held. The descriptive statistics and the estimated models are presented as follows.

3.1. Descriptive statistics

Statistically significant variables at the 5% level were kept in the models W_1 to W_7. They were grouped into building, electricity, costs, business and respondent related variables as described in Table 2, followed by their mean value and standard deviation.

As can be seen from Table 2, the mean office space was about 77 m^2. 22.2% of the companies surveyed in this research were located in buildings constructed before 1980, 27.6% in buildings constructed between 1981 and 1990, 32.4% between 1991 and 2000 and the remaining 17.8% between 2001 and 2005. In 1979 the thermal code for buildings was issued in Greece [53], therefore all buildings constructed before 1980–81 have no insulation. As far as electricity is concerned Crete is autonomous as it is an island and not connected by cable to the mainland. During the tourist season, malfunctions or short electricity shortages may occur due to the high peak power demand. In the survey 9.6% of the respondents reported no electricity shortages, 50.3% reported shortages once per year, 22.8% reported shortages 2–5 times and 9.6% reported shortages more than 10 times. In fact 69% of the respondents claimed, the company they manage, to be highly affected by electricity shortages.

In offices which were not fully equipped with energy efficient lamps, it was estimated that the average cost of replacing the remaining incandescent lamps with these energy efficient lamps was 10.65€ per office. The average investment for occupancy lighting sensors in the office was estimated at 34.77€ per office. The average replacement cost for all conventional fluorescence lamps with up to date system of fluorescence lamps was estimated at 271.01€ per office.

Of the surveyed companies 87% dealt with services and 13% with trade. 80.8% of these companies were private, 10.6% was partnership or limited partnership and 8.6% was incorporation or limited liability. The average annual turnover of the surveyed companies was 162,838€. The average number of the persons working in the office was 2.88.

The average age of the company managers was 42 years old. With regard to their education, 0.3% of them had only primary school level, 22.8% secondary school, and 76.9% were college or university graduates. Almost half of the respondents (47.2%) claimed to

Table 2
List of variables and descriptive statistics for models W_1 to W_7 ($n = 685$).

Variable	Description	Mean	Standard deviation
Building			
SM	Square meters of the floor area of office facilities	76.980	118.220
Y1	Year of construction of the building: 1 = before 1980, 0 = otherwise	0.222	0.416
Y2	Year of construction of the building: 1 = 1981–1990, 0 = otherwise	0.276	0.447
Y3[a]	Year of construction of the building: 1 = 1991–2000, 0 = otherwise	0.324	0.468
Electricity			
BA1	Average annual number of electricity shortages: 1 = never, 0 = otherwise	0.096	0.295
BA2	Average annual number of electricity shortages: 1 = 1 time, 0 = otherwise	0.503	0.501
BA3	Average annual number of electricity shortages: 1 = 2–5 times, 0 = otherwise	0.228	0.420
BA4[b]	Average annual number of electricity shortages: 1 = 6–10 times, 0 = otherwise	0.096	0.295
BAI	Negative impacts of the electricity shortages on the company: 1 = yes, 0 = no	0.690	0.461
Costs			
CLAMP	Replacement cost of incandescent lamps with energy efficient lamps (€)	10.65	17.604
CSENSOR	Estimated investment for occupancy lighting sensors in the office (€)	34.77	28.090
CFLUOR	Estimated replacement cost of all old fluorescence lamps with the up to date system of fluorescence lamps (€)	271.01	457.656
Business			
SUB	Business activity: 1 = services, 0 = trade	0.870	0.333
L1	Business form: 1 = private company, 0 = otherwise	0.808	0.395
L2[c]	Business form: 1 = partnership or limited partnership, 0 = otherwise	0.107	0.310
BAL	Turnover for the year 2005	162,838	329,032
PER	Number of persons working in the office	2.880	4.182
Respondent			
AGE	Age of the respondent	41.980	10.318
EDU1	Education level: 1 = primary school but not higher, 0 = otherwise	0.003	0.054
EDU2[d]	Education level: 1 = Jr. or Sr. high school but not higher, 0 = otherwise	0.228	0.420
INFO	Informed about energy saving: 1 = informed, 0 = not informed	0.472	0.500
NT	Aware that they can save energy with the use of new technology and appliances: 1 = yes, 0 = no	0.750	0.431
ATT	Aware that they can have significant energy saving with the appropriate behavior: 1 = yes, 0 = no	0.860	0.343

[a] The reference category is 2001–2005.
[b] The reference category is more than 10 times.
[c] The reference category is Incorporation or Limited Liability Company.
[d] The reference category is University or College graduate.

be informed about energy saving and energy efficiency, while 75% stated that they were aware of energy saving through the use of new technology and appliances. In addition, 86% claimed to be aware that they can save energy by the appropriate behavior. These results indicate that there is still a role for specific awareness campaigns for energy saving and energy efficiency.

Respondents were asked if sensors of natural lighting, occupancy lighting sensors, local lighting (*e.g.* abattoir) or timer had been installed in the office. Such devises reduce significantly electricity consumption and improve the indoor visual environment [54,55]. The responses are reported in Table 3. About half of the offices (47.4%) had no lighting saving device installed, however, there were offices with more than one lighting saving/efficiency device.

3.2. Percentage of energy efficient lamps

The dependent variable of this model is the percentage of the watts corresponding to the energy efficient lamps. The cumulating

Table 3
Saving devices for lighting in the offices.

Saving device	Frequency	Percent (%)
Sensors of natural lighting	20	2.9
Occupancy lighting	56	8.2
Local lighting	189	27.6
Timer	140	20.4
None of the above	360	52.6

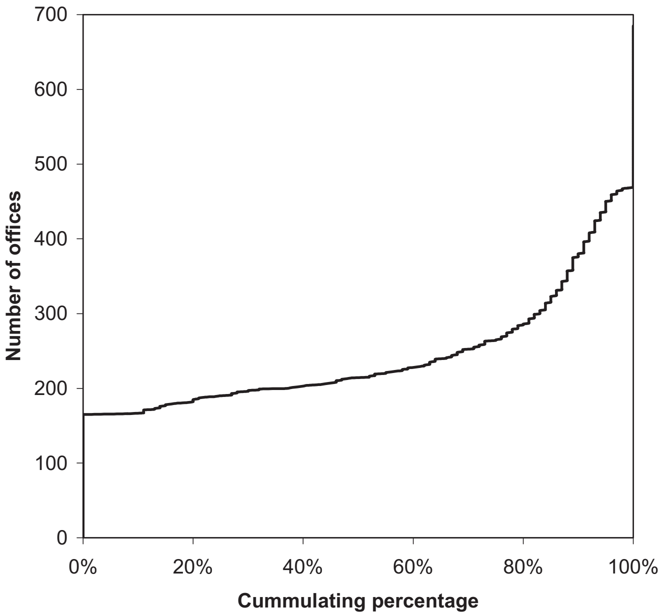


Fig. 1. The cumulating percentage of energy saving lamps in the offices.

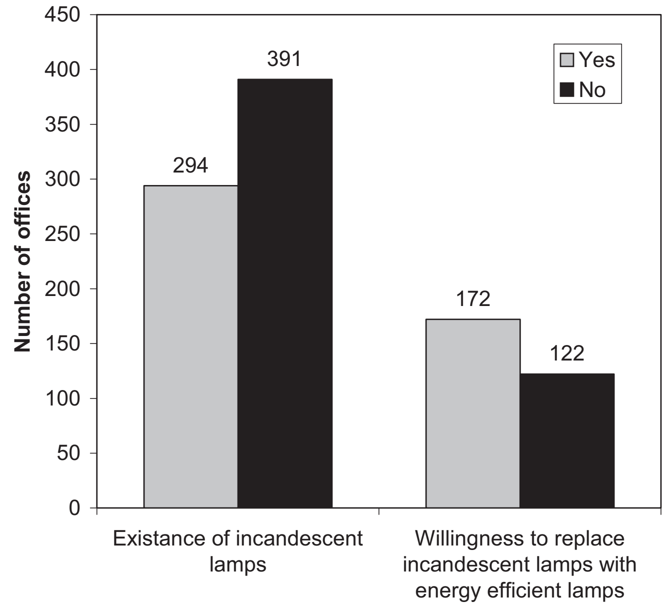


Fig. 2. Existence of incandescent lamps and willingness to replace them with energy efficient lamps in the offices.

percentage of energy saving lamps in the offices is shown in Fig. 1 as calculated by Eq. (1). It was observed that 165 (24.1%) offices had not installed even one lamp of low energy consumption, while 217 (31.7%) had installed all their lighting power in energy efficient lamps. The dependent variable (W_1) represents the percentage of energy efficient lamps installed, a continuous variable ranging from 0% to 100%.

Tobit regression was used and significant variables at 5% level were kept in the model. The estimated coefficients of the explanatory variables followed by their significances are given in Table 4. These variables indicate a higher or lower percentage of energy efficient lamps.

Those offices where companies with higher turnover (BAL) were located had greater percentages of energy efficient lamps ($\widehat{\beta} = 8.26 \times 10^{-8}$, $p = 0.033$), which indicates the need for subsidies, appropriate incentives, support programs and awareness campaigns for low turnover companies. Furthermore offices where the cost of replacement of all incandescent lamps (CLAMP) by energy saving ones was high, were found to be less likely to have high coverage with energy efficient lamps ($\widehat{\beta} = -0.024$, $p < 0.001$). This means that the high initial cost, due to the need to replace many incandescent lamps, leads to the installation of less energy efficient lamps. As expected those managers who considered themselves to be informed on energy saving (INFO) were more likely to have installed a higher percentage of energy efficient lamps ($\widehat{\beta} = 0.070$, $p = 0.015$) in the offices. According to Cowan and Daim [49], low installation cost and energy cost savings are two of the most common factors for adopting energy efficiency technology for lighting in commercial buildings; total cost of ownership, lighting color and start up speed are other important factors.

Table 4
Results for model W_1 ($n = 685$).

Variables and statistics	$\hat{\beta}$	t	p
C	0.707	13.141	<0.001
BAL	8.26×10^{-8}	2.134	0.033
INFO	0.070	2.431	0.015
CLAMP	−0.024	−8.299	<0.001
σ	0.370	17.023	<0.001
−2 LL	−365.751		
Adjusted R^2	0.522		

3.3. Have installed at least one energy efficient lamp and willingness to replace all incandescent lamps with energy efficient lamps

It was found that 294 (42.92%) of the offices had at least one incandescent lamp (Fig. 2). However, after the information session 172 of the managers in these offices stated their willingness to replace these lamps with energy efficient ones.

Results for model W_2 are presented in Table 5. The larger the office floor (SM), the lower the probability of it having at least one energy efficient lamp ($\widehat{\beta} = -0.002$, $p = 0.015$). Those offices, where the cost of fully replacing incandescent lamps with energy efficient lamps is high (CLAMP), have a lower probability of having installed at least one energy efficient lamp ($\widehat{\beta} = -0.009$, $p < 0.001$). Therefore offices with low lighting needs and a small floor area are more likely to have an energy efficient lamp than larger offices with more lighting requirements and greater floor surface. When managers stated that their companies were often affected by the electricity shortages (BAI), they were more likely to have installed at least one energy efficient lamp ($\widehat{\beta} = 0.633$, $p = 0.007$), which suggests that they were concerned about the energy availability and hence had become better energy savers. Furthermore the greater the number of persons working in the office (PER), the more probable it was to find at least one energy efficient lamp ($\widehat{\beta} = 0.359$, $p < 0.001$). This would suggest that the employees of larger companies influence the management concerning lighting saving.

Managers who claimed to be aware that energy saving can be achieved through the appropriate behavior (ATT) were more likely to have already installed at least one energy efficient lamp ($\widehat{\beta} = 0.728$, $p = 0.012$) compared to those who did not. This confirms the importance of the role of information and energy awareness in energy saving behavior [55,56]. Older respondents (AGE) were also more likely to have installed an energy efficient lamp ($\widehat{\beta} = 0.029$, $p = 0.012$). Electrical lighting was regarded as a “luxury”, expensive good and not an “ordinary good” some decades ago. Many older people in Greece perceive, although sometimes unconsciously,

Table 5
Results for models W_2 and W_3.

Variables and statistics	Model W_2 ($n = 685$)			Model W_3 ($n = 294$)		
	$\widehat{\beta}$	Wald χ^2	p	$\widehat{\beta}$	Wald χ^2	p
C	−1.036	2.263	0.132	−0.920	8.468	0.002
ATT	0.728	6.291	0.012			
BAI	0.633	7.404	0.007			
SM	−0.002	5.901	0.015			
PER	0.359	14.458	<0.001			
CLAMP	−0.009	115.256	<0.001	3.40×10^{-4}	8.446	0.004
AGE	0.029	6.297	0.012			
EDU		6.096	0.047			
EDU1	18.726	0.000	0.999			
EDU2	−0.642	6.096	0.014			
Y					9.647	0.022
Y 1				0.595	3.827	0.046
Y 2				0.584	4.013	0.051
Y 3				0.008	0.001	0.087
BAL				9.539×10^{-7}	4.029	0.045
Pseudo R^2		0.354			0.118	
−2 LL		571.661			611.573	
Hosmer and Lemeshow test		4.431	0.816		31.268	0.447
Overall predictive accuracy		81%			79.3%	

better the energy problem and act in an energy efficient and energy-wise manner. In fact those people who got connected to electricity as adults appreciate it usually more and save it. Savvanidou et al. [57] reported that older people express more concern about the shortage of energy resources. As expected companies with managers of secondary education (EDU2) were on average less energy saving compared to those run by managers of college or university education ($\widehat{\beta} = -0.642$, $p = 0.014$) [58]. As can be observed in Tables 4 and 5 models W_1 and W_2 are explained by different variables since they include different dependent variables. The first explains the more wise saving behavior, while the second explains if there is any saving behavior for lighting purposes.

Results for model W_3 are presented in the right panel of Table 5. Managers from companies located in buildings constructed before 1990 (Y1 and Y2) were more willing to replace the incandescent lamps with energy efficient ones ($\widehat{\beta} = 0.595$, $p = 0.046$ and $\widehat{\beta} = 0.584$, $p = 0.051$, respectively). This is probably because these offices were equipped upon construction with old technology lighting devices, resulting in high electricity bills. The information session had positive effects on their willingness to replace the existing lighting with new efficient ones since it is the most convenient and cost effective step they can take to lower their electricity bills. Those offices with higher turnovers (BAL) were more probable to be willing to replace incandescent lamps with energy efficient lamps ($\widehat{\beta} = 9.539 \times 10^{-7}$, $p = 0.045$). Those offices, where the cost (CLAMP) of replacing the incandescent lamps with energy efficient lamps is high, are more willing to undertake this cost ($\widehat{\beta} = 3.4 \times 10^{-4}$, $p = 0.004$). This finding indicates that those offices with high lighting needs are more likely to view lamp replacement positively. Furthermore, this positive sign could be attributed to the high benefit–cost ratio and the low initial cost investment. This is due to the fact that managers realize the financial benefits that apply to businesses with higher lighting needs. Reasons that make respondents reluctant to install energy efficient lamps are listed in Table 6 followed by the reported frequency.

Table 6
Reasons for being reluctant to install energy efficient lamps.

Reason	Frequency
I don't have the money	1
I don't like the light of energy efficient lamps	42
There is no real net benefit	36
I like incandescent lamps	25
I do not want to be bothered with the process of replacing lamps	57
It doesn't fit my lamp holder	2

3.4. *Existence of an occupancy lighting sensor and willingness to install them in auxiliary space*

Only 56 managers from those asked had installed an occupancy lighting sensor as shown in Fig. 3. Of the remaining, 171 were positive about installing occupancy lighting sensors after the information session.

Results for model W_4 are given in the left panel of Table 7. Light occupancy sensors were most likely found in companies located in buildings constructed after 2001 (reference category) which indicates that nowadays such devices are installed upon construction. Moreover, those offices that had installed light occupancy

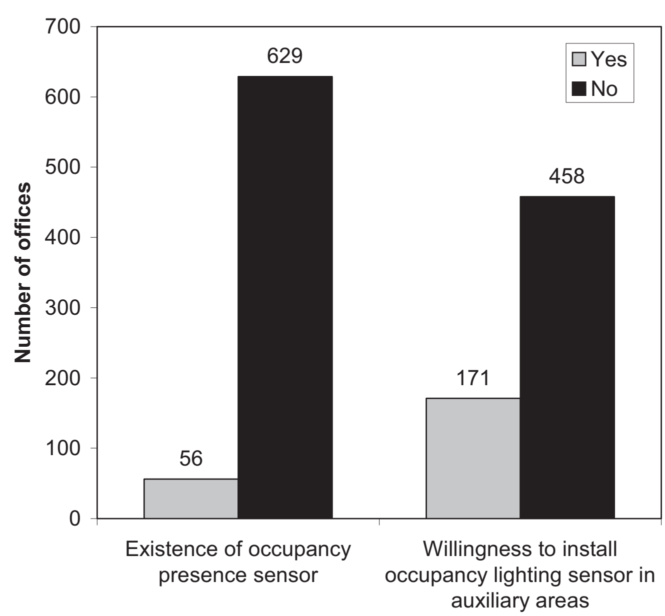


Fig. 3. Existence and willingness to install occupancy lighting sensors in auxiliary space.

Table 7
Results for models W_4 and W_5.

Variables and statistics	Model W_4 ($n=685$)			Model W_5 ($n=629$)		
	$\hat{\beta}$	Wald χ^2	p	$\hat{\beta}$	Wald χ^2	p
C	−1.936	52.293	<0.001	−1.375	69.543	<0.001
Y		8.884	0.031			
Y1	−0.915	4.472	0.034			
Y2	−1.171	7.378	0.007			
Y3	−0.482	1.875	0.171			
$(\text{CSENSOR})^2$	4.989×10^{-5}	5.919	0.015			
SM				0.009	23.003	<0.001
Pseudo R^2		0.049			0.074	
−2 LL		373.056			663.492	
Hosmer and Lemeshow test		17.292	0.616		21.200	0.789
Overall predictive accuracy		92%			75.8%	

sensors were found to have installed many of them. This is shown implicitly by the positive sign of the CSENSOR squared variable ($\hat{\beta} = 4.989 \times 10^{-5}$, $p=0.015$). This indicates that once this energy saving action is decided, it is more likely that the office will be fully equipped since there are gains from economies of scale.

Results for model W_5 are given in Table 7. The larger the office (SM) the more willing the respondents were to install occupancy lighting sensors ($\hat{\beta} = 0.009$, $p<0.001$). This may be explained by the fact that large space offices have more auxiliary rooms and this energy efficient apparatus will generate gains, once decided and implemented.

3.5. Have installed up to date efficient systems of fluorescence lamps and willingness to replace the conventional fluorescent lighting systems with them

Fig. 4 shows that out of the 433 offices that had fluorescence lamps only 69 of them had at least one up to date (advanced) system of fluorescence lamps. Of the remaining 364 offices with conventional fluorescence lamps the managers of 132 (36.26%) of them stated willing to replace the conventional fluorescence lamps with the up to date system.

Results for model W_6 are given in the left panel of Table 8. The respondents who claimed to be informed about energy saving (INFO) were more likely to have installed up to date efficient systems of fluorescence lamps ($\hat{\beta} = 0.416$, $p=0.020$). Similarly, those claiming to be aware that they can save energy by the use of new technology and appliances (NT) were more likely to have installed up to date efficient systems of fluorescence lamps ($\hat{\beta} = 0.409$, $p=0.044$). These last two variables support, once more the role of information and awareness in lighting efficiency/saving investments [33]. Companies with main activity services (SUB) were more probable to have installed up to date efficient systems of fluorescence lamps compared to trade companies ($\hat{\beta} = 0.508$, $p=0.039$). This finding indicates that companies providing services put more emphasis on efficient lighting, compared to those companies dealing with trade, since the main activity in the offices is mostly desk work based. As expected companies with high turnover (BAL) were more likely to have installed up to date efficient systems of fluorescence lamp ($\hat{\beta} = 8.634 \times 10^{-7}$, $p=0.040$), since this investment requires considerable investment cost. Companies with more employed personnel (PER) were also more likely to have installed up to date efficient systems of fluorescence lamps ($\hat{\beta} = 0.111$, $p=0.030$), similarly to the findings of model W_2.

Results for model W_7 are given in the right panel of Table 8. Exploratory variables of this model differ from W_3 because although the dependant variables refer to efficient lighting technology, agreement to undertake the investments differ in terms of capital cost, payback period and benefit to cost ratio. Those managers who claimed to be informed about energy saving (INFO) were more willing to install the AFLs ($\hat{\beta} = 0.572$, $p=0.027$). However, those who claimed to be aware that they could have significant energy saving with appropriate behavior (ATT) were less willing to install the AFLs ($\hat{\beta} = -0.942$, $p=0.018$), which suggests that there is a specific lack of information on cost efficiency. The managers who reported more than 10 electricity shortages per year (reference category for BA), they were on average more willing to install AFLs than managers who had less electricity shortages, which was an expected finding. Respondents from larger offices (SM) were more willing to install AFLs ($\hat{\beta} = 0.005$, $p=0.018$), which could be due to the fact that they save in total more compared to small offices.

Managers from private companies (L1) were more willing to install AFLs ($\hat{\beta} = 1.054$, $p=0.005$) compared to incorporations or limited liability companies. This is probably related to their direct personal involvement in paying the electricity bill and therefore knowing the cost of electricity. Furthermore, in big companies, decisions for energy saving matters are more complicated than in personal businesses. The ratio of the natural logarithm for the cost of installing AFLs by the natural logarithm of the turnover (LN(CFLUOR)/LN(BAL)) has a negative relationship with the willingness to install AFLs systems ($\hat{\beta} = -8.770$, $p<0.001$). This shows the reluctance of businesses which have great number of conventional lamps and are not very wealthy to invest in this energy saving technology. In such cases, proper incentives, awareness campaigns

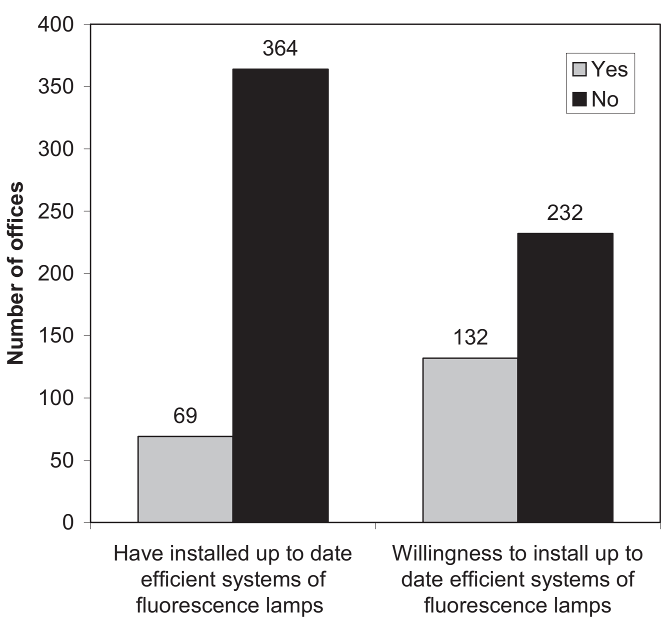


Fig. 4. Have installed up to date efficient systems of fluorescence lamps and willingness to replace the conventional fluorescent lighting systems in place.

Table 8
Results for models W_6 and W_7.

Variables and statistics	Model W_6 (n = 685)			Model W_7 (n = 364)		
	$\hat{\beta}$	Wald χ^2	p	$\hat{\beta}$	Wald χ^2	p
C	−1.762	10.285	0.001	3.847	12.616	0.000
INFO	0.416	5.448	0.020	0.572	4.863	0.027
NT	0.409	4.057	0.044			
SUB	0.508	4.246	0.039			
BAL	8.634×10^{-7}	4.227	0.040			
PER	0.111	4.703	0.030			
ATT				−0.924	5.553	0.018
BA					12.309	0.015
BA1				−21.144	0.000	0.999
BA2				−1.777	11.969	0.001
BA3				−1.150	7.721	0.005
BA4				−1.097	5.828	0.016
SM				0.005	5.557	0.018
L					7.942	0.019
L1				1.054	7.941	0.005
L2				0.774	1.025	0.311
LN(CFLUOR)/LN(BAL)				−8.770	21.326	<0.001
Pseudo R^2		0.078			.224	
−2 LL		866.356			411.073	
Hosmer and Lemeshow test		7.225	0.513		8.391	0.396
Overall predictive accuracy		66%			69.7%	

and subsidies to low budget companies may bring a mutual benefit for the businesses and society.

4. Conclusions

This research recognized the fundamental role of energy awareness and therefore integrated a targeted information session, on technical and cost recovery issues, conducted by the researcher for the interviewed company manager which used photos and comprehensive figures for the lighting technologies and lighting occupancy sensors. Moreover, the researchers were on site to guide and help the respondents to assess and calculate the necessary energy saving data in order to ensure that the questionnaire was completed correctly by having quantified data in terms of energy efficiency and cost saving of the proposed interventions. The revealed and stated preferences resulted in findings that can help with energy saving and energy efficiency policies for lighting in offices beyond the case study region, since business principles do not differ from country to country. The results of this work suggest that a proper policy would be to keep the energy awareness level high for office managers. Furthermore proper incentives or even subsidizing initial investment costs in companies with high needs and low annual turnover should be undertaken. This would benefit not only the financial profiles of the companies but also energy efficiency and as a consequence the environment and society in general. In addition, the methodology applied and analysis could be the starting point for local or regional authorities or other administrative bodies wishing to investigate the penetration of energy saving and form a relevant policy based on public participation and attitudes.

Promoting energy saving programs in regions without fully reliable electricity supply would facilitate energy saving and benefit power supply utilities since in those regions companies would be more willing to participate in energy saving investments for efficient lighting. Furthermore, focus should be given to businesses located in old buildings. A proposed project would be to massively install in "office neighborhoods" occupancy lighting sensors by subsidizing or organizing a project by an electricity producing utility or a Ministry. Managers seem willing to participate, but because of the low cost and high managing time, the penetration of some energy saving apparatus was not very widespread. Follow up research should focus on consumer satisfaction, and more specifically on the effects users had from the new lighting technologies on their working environment.

Reported results are useful for the successful implementation of the 2002/91/EC "Energy Performance of Buildings Directive" – EPBD [3], which is incorporated into the Greek legislation 2008/3661/GR [59], for generating energy data for office buildings and for becoming a base for marketing of office efficient energy devices and products. As a result, in Crete, there are nearly twenty new companies dealing with the consulting–promotion–implementation of energy efficiency and renewable energy sources mainly for the building sector. On the other hand, commercial firms selling office energy efficient devices could be helped to improve their marketing.

Finally, these results could form basis of a specific "Action and Implementation Plan" for energy efficiency in the office sector and planning – implementation measures and investments programs for energy efficiency policies and campaigns at a regional level. Except for the obvious advantages in creating new activities and new jobs, promoting energy innovation and protecting the environment, this plan could contribute seriously to the fulfillment of the Greek National legally binding targets for 20% Energy Efficiency and 4% emissions reduction in 2020 for climate change mitigation [60] and therefore to the European targets of 20-20-20.

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References

[1] COM. Communication from the Commission to the European Parliament the Council, the European Economic and Social Committee of the Regions, Second Strategic Energy Review, An EU Energy Security and Solidarity Action Plan. SEC(2008)2870, SEC(2008)2871, SEE(2008/2872). COM(2008)781 final, Brussels, 13.11.2008. 21pp.

[2] COM. Action plan for energy efficiency: realising the potential. Communication from the Commission, Commission of the European Communities,

COM(2006)545 final, Brussels, 19.10.2006. Available from: http://ec.europa.eu/energy/action_plan_energy_efficiency/doc/com_2006_0545_en.pdf; 2006 [accessed 05.08.11].
[3] EC. Directive 2002/91/EC of the European Parliament and of the Council on the energy performance of buildings. Off J Eur Commun L 2003;1:65–71.
[4] COM. Green paper: a European strategy for sustainable, competitive and secure energy. Communication from the Commission, Commission of the European Communities, COM(2006)105 final, Brussels, 8.3.2006. Available from: http://ec.europa.eu/energy/green-paper-energy/doc/2006_03_08_gp_document_en.pdf; 2006 [accessed 05.08.11].
[5] Balaras CA, Gaglia AG, Georgopoulou E, Mirasgedis S, Sarafidis Y, Lalas DP. European residential buildings and empirical assessment of the Hellenic building stock, energy consumption, emissions and potential energy savings. Build Environ 2007;42:1298–314.
[6] Klein M. Government support for energy saving projects. In: Traunmüller R, editor. Electronic government. Heidelberg: Springer Berlin; 2004. p. 97–101.
[7] Ürge-Vorsatz D, Novikova A. Potentials and costs of carbon dioxide mitigation in the world's buildings. Energy Policy 2008;36:642–61.
[8] de Ia Rue du Can S, Price L. Sectoral trends in global energy use and greenhouse gas emissions. Energy Policy 2008;36:1386–403.
[9] Pérez-Lombard L, Ortiz J, Pout C. A review on buildings energy consumption information. Energy Build 2008;40:394–8.
[10] Waide P, Lebot B, Hinnells M. Appliance energy standards in Europe. Energy Build 1997;26:45–67.
[11] Dascalaki E, Santamouris M. On the potential of retrofitting scenarios for offices. Build Environ 2002;37:557–67.
[12] Markis T, Paravantis JA. Energy conservation in small enterprises. Energy Build 2007;39:404–15.
[13] Scrase JI. Curbing the growth in UK commercial energy consumption. Build Res Inform 2001;29:51–61.
[14] Santamouris M, Dascalaki E. Passive retrofitting of office buildings to improve their energy performance and indoor environment. The OFFICE project. Build Environ 2002;37:575–8.
[15] Leaman A, Bordass B. Productivity in buildings: the 'killer' variables. Build Res Inform 1999;27:4–19.
[16] Georgopoulou E, Sarafidis Y, Mirasgedis S, Balaras CA, Gaglia A, Lalas DP. Evaluating the need for economic support policies in promoting greenhouse gas emission reduction measures in the building sector: the case of Greece. Energy Policy 2006;34:2012–31.
[17] OECD/IEA. Light's labour's lost: policies for energy-efficient lighting, energy efficiency policy profiles. Paris Cedex 15, France: International Energy Agency (IEA). p. 558. Available from: http://www.iea.org/textbase/nppdf/free/2006/light2006.pdf; 2006 [accessed 25.04.11].
[18] Augenbroe G, Park CS. Quantification methods of technical building performance. Build Res Inform 2005;33:159–72.
[19] Mortimer ND, Ashley A, Moody CAC, Rix JHR, Moss SA. Carbon dioxide savings in the commercial building sector. Energy Policy 1998;26:615–24.
[20] Jenkins D, Liu Y, Peacock AD. Climatic and internal factors affecting future UK office heating and cooling energy consumptions. Energy Build 2008;40: 874–81.
[21] Santamouris M, Argiriou A, Dascalaki E, Balaras C, Gaglia A. Energy characteristics and savings potential in office buildings. Solar Energy 1994;52:59–66.
[22] Ng IWH, Deng S. A parametric analysis on energy and cost saving potentials of implementing demand side management (DSM) measures in Hong Kong's office buildings. Trans Hong Kong Inst Eng 2002;9:34–8.
[23] EC. Directive 2000/55/EC of the European Parliament and Council Directive of the 18 September 2000, on energy efficiency requirements for ballasts for fluorescent lighting. Off J Eur Commun L 2000;279:33–8.
[24] IEA. Energy policies and programmes of IEA countries. OECD/IEA, Paris. International Energy Agency; 1989.
[25] Jacob B. Lamps for improving the energy efficiency of domestic lighting. Light Res Technol 2009;41:219–28.
[26] Murakami Y, Terano M, Obayashi F, Honma M. Development of cooperative building controller for energy saving and comfortable environment; 2007. p. 1078–87.
[27] Wang N, Boubekri M. Design recommendations based on cognitive, mood and preference assessments in a sunlit workspace. Light Res Technol 2011;43: 55–72.
[28] Dubois M-C, Blomsterberg Å. Energy saving potential and strategies for electric lighting in future North European, low energy office buildings: a literature review. Energy Build 2011;43:2572–82.
[29] Graeber N, Papamichael K. Smart corridors light the way to energy efficiency: managing the lighting in secondary spaces such as stairwells, lobbies and service rooms based on occupancy can carve a big chunk out of overall energy use. Light Des Applicat: LD&A 2011;41:52–4.
[30] Menanteau P, Lefebvre H. Competing technologies and the diffusion of innovations: the emergence of energy-efficient lamps in the residential sector. Res Policy 2000;29:375–89.
[31] Mills E. Evaluation of European lighting programmes: utilities finance energy efficiency. Energy Policy 1991;19:266–78.
[32] Nielsen B. Load-shape data for residential lighting: survey results for incandescent and compact fluorescent lamps. Energy 1993;18:211–7.
[33] Kumar A, Jain SK, Bansal NK. Disseminating energy-efficient technologies: a case study of compact fluorescent lamps (CFLs) in India. Energy Policy 2003;31:259–72.
[34] Johnson K, Unterwurzacher E. Ensuring market supply and penetration of efficient lighting technologies. Energy 1993;18(IN3):163–70.
[35] Rave K. A contract for efficient lighting in German public buildings. Energy 1993;18:159–61.
[36] Hansen DM. New DOE efficiency standards for lamps. Light Des Applicat: LD&A 2010;40:20–1.
[37] EC. Directive 98/11/EC European Commission of 27 January 1998 implementing Council Directive 92/75/EEC with regard to energy labelling of household lamps L. 71; 1998, pp. 1–10.
[38] OECD/IEA. Energy policies of IEA countries: Greece 2002 review. Paris: International Energy Agency and Organisation for Economic Co-Operation and Development; 2002. p. 114. Available from: http://www.iea.org/textbase/nppdf/free/2000/greece2002.pdf [accessed 20.08.09].
[39] IEA. Energy technology perspectives. OECD/IEA, Paris. International Energy Agency; 2006.
[40] IPPC. Climate change. Fourth assessment report of the IPCC. Cambridge University Press, Cambridge. Intergovernmental Panel on Climate Change; 2007.
[41] UNEP. Buildings and climate change: status, challenges, and opportunities. United Nations Environmental Programme; 2007.
[42] Van Tichelen P, Jansen B, Geerken T, Vanden Bosch M, VanHoof V, Vanhooydonck L, et al. Office lighting, preparatory studies for eco-design requirements of EuPs. European Commission DGTREN unit D3. p. 271. Available from: http://www.eup4light.net/assets/pdffiles/Final/vitoeupofficelightingfinal.pdf; 2007 [accessed 05.08.11].
[43] Enercyregio. Action Programme for Strengthening the Energy Efficiency and Source Saving by Sustainable Local Development in European Regions; 2007. Available from: http://www.interreg3c.net/sixcms/detail.php\?id=6977; 2007 [accessed 05.08.11].
[44] Tsagarakis KP, Karyotakis K, Zografakis N. Implementation conditions for energy saving technologies and practices in office buildings: Part 2, double glazing windows, heating and air-conditioning. Renew Sustain Energy Rev, doi:10.1016/j.rser.2012.03.007, forthcoming.
[45] Soori PK, Alzubaidi S. Study on improving the energy efficiency of office building's lighting system design. In: IEEE GCC conference and exhibition. 2011. p. 585–8 [Article number 5752604].
[46] MEDCLIMA. Manual for energy saving for climate protection, LIFE-ENVIRONMENT project in Greek. Available from: http://www.medclima.gr/documents/guidance_docs_citizens.pdf; 2004 [accessed 20.08.09].
[47] REAC. Energy Saving Estimation for Crete. Regional Energy Agency of Crete. Unpublished data, 2006, Crete, Greece; 2006.
[48] Yuen GSC, Sproul AB, Dain SJ. Performance of 'energy efficient' compact fluorescent lamps. Clin Exp Optom 2010;93:66–76.
[49] Cowan KR, Daim TU. Understanding adoption of energy efficiency technologies: applying behavioral theories of technology acceptance & use to understand the case of led lighting for commercial, residential, and industrial end-users. In: PICMET: Portland International Center for Management of Engineering and Technology, proceedings. 2011 [Article number 6017904].
[50] Eltamaly AM, Alolah AI, Malik NH, Bawah U, Yousef MJ. Criteria for comparison of energy efficient lamps. In: Proceedings – ISIE 2011: 2011 IEEE international symposium on industrial electronics. 2011. p. 1017–22 [Article number 5984299].
[51] Dolara A, Faranda R, Guzzetti S, Leva S. Power quality in public lighting systems. In: 14th International conference on harmonics and quality of power, ICHQP 2010. 2010 [Category number 10EX4452; Code 82910].
[52] van Bommel W. Lighting quality and energy efficiency, a critical review. Light Eng 2011;19:5–11.
[53] Greek Government Buildings Thermal Code. Official Journal of the Greek Government, Presidential Decree 4-7-/1979, Official Journal of the Greek Government, 362/D'/4 July 1979.
[54] Choi AS, Song KD, Kim YS. The characteristics of photosensors and electronic dimming ballasts in daylight responsive dimming systems. Build and Environ 2005;40:39–50.
[55] Doulos L, Tsangrassoulis A, Topalis F. Quantifying energy savings in daylight responsive systems: the role of dimming electronic ballasts. Energy Build 2008;40:36–50.
[56] Yavuz C, Yanikoğlu E, Güler Ö. Determination of real energy saving potential of daylight responsive systems: a case study from Turkey. Light Eng 2010;18:99–105.
[57] Savvanidou E, Zervas E, Tsagarakis KP. Public acceptance of biofuels. Energy Policy 2010;38:3482–8.
[58] Tsagarakis KP, Bounialetou F, Gillas K, Profylienou M, Pollaki A, Zografakis N. Tourists' attitudes for selecting accommodation with investments in renewable energy and energy saving systems. Renew Sustain Energy Rev 2011;15:1335–42.
[59] Greek Government Energy saving measures in buildings and other structures. Off J Greek Government, L.3661, A 2008;89:1371–7 [in Greek].
[60] Greek Ministry of Development. Presentation of the program "Energy Saving in Households". Introductory speech by the Minister 28/7/2009. Available from: http://www.ypan.gr/c_announce/45_5545_cms.htm; 2009 [accessed 05.08.11] [in Greek].